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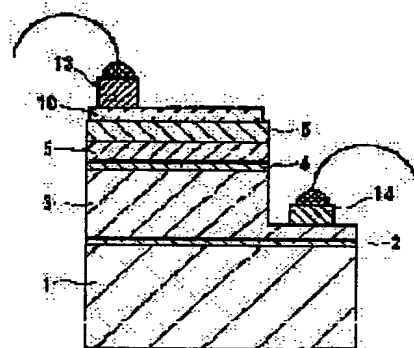
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(54) NITRIDE SEMICONDUCTOR LIGHT EMITTING ELEMENT

(57)Abstract:

PROBLEM TO BE SOLVED: To improve the light transmissivity of a nitride semiconductor light emitting element by forming a translucent electrode containing at least vanadium on almost the entire surface of the p-type layer of the light emitting element on which the p-type layer is formed as the outermost layer.

SOLUTION: After a buffer layer 2, an n-type contact layer 3, an active layer 4, a p-type clad layer 5, and a p-type contact layer 6 are successively grown on a sapphire substrate 1, a mask is formed in a prescribed shape on the surface of the topmost p-type GaN contact layer 6 and part of the contact layer 3 is exposed by etching the layers 4, 5, and 6. Then the mask is removed from the surface of the contact layer 6 and Pd is vapor-deposited to a film thickness of 300Å on almost the entire surface of the topmost GaN layer 6 as a p-electrode 10. The translucent electrode 10 containing Pd transmits visible light, especially, visible light of purple to green color more than the conventional translucent electrode does. Therefore, when the electrode 10 is formed on the surface of the p-type layer 6, the light transmissivity of a nitride semiconductor light emitting element can be improved.



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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Industrial Application] this invention relates to the electrode of the light emitting device which starts light emitting devices, such as Light Emitting Diode to which it comes to carry out the laminating of the nitride semiconductor ($\text{In}_x\text{Al}_{1-x}\text{Ga}_{1-y}\text{N}$, $0 \leq x, 0 \leq y, x+y \leq 1$), especially by which p type nitride semiconductor layer was formed in the maximum front face.

[0002]

[Description of the Prior Art] Now, blue Light Emitting Diode and green Light Emitting Diode using the nitride semiconductor ($\text{In}_x\text{Al}_{1-x}\text{Ga}_{1-y}\text{N}$, $0 \leq x, 0 \leq y, x+y \leq 1$) are put in practical use. The fundamental structure of these Light Emitting Diodes is n type nitride semiconductor layer (it is hereafter called n layers.) which consists of n mold $\text{Al}_y\text{Ga}_{1-y}\text{N}$ ($0 \leq y \leq 1$) on a transparent insulating substrate. The barrier layer which consists of $\text{In}_x\text{Ga}_{1-x}\text{N}$ ($0 < x \leq 1$), and p type nitride semiconductor layer which consists of p mold $\text{Al}_z\text{Ga}_{1-z}\text{N}$ ($0 \leq z \leq 1$) (it is hereafter called p layers.) It has a structure to the double by which the laminating was carried out to order. Since this Light Emitting Diode cannot take out n electrode from a substrate side, it considers as the so-called flip chip form which takes out n electrode and p electrode from the same side side. A luminescence observation side side has many by which the electrode, i.e., p layers, side is made the luminescence observation side, although it also becomes a side someday a substrate and electrode side, since the substrate is transparent.

[0003] In order to take out luminescence of a barrier layer outside, the electrode which consists of a metal of a translucency is prepared in p layers which become a luminescence observation side side. Moreover, we showed the light emitting device by which the metal electrode of a translucency was prepared in the front face of p layers in JP,6-314822,A. However, in the metal electrode of the conventional translucency, the permeability of the electrode to blue and green light was bad, and was not what it can still be satisfied [with an external quantum efficiency] of enough.

[0004] By the way, the electrode used for the light emitting device which consists of semiconductor materials, such as Light Emitting Diode, needs to obtain the semiconductor material and desirable ohmic contact, in order to reduce forward voltage. Also in Above Light Emitting Diode, desirable ohmic contact has been obtained by the electrode which contains Ti and aluminum in n layers, and the electrode which contains nickel and Au in p layers.

[0005] In addition, the tin oxide, indium oxide, and the zinc oxide are shown in JP,5-55631,A as an electrode material formed in a nitride semiconductor. However, the material shown in this official report is an electrode formed in the i (insulating) type nitride semiconductor which doped acceptor impurity, and is not desirable ohmic ***** and the electrode formed in p layers. Moreover, although Ag, Au, Pt, Ir, Pd, Rh, etc. are stated to JP,5-315647,A as a desirable electrode formed in p layers, only Au electrode is prepared in i layers of the light emitting device of not p type but MIS structure in fact.

[0006]

[Problem(s) to be Solved by the Invention] A crystal growth is a very difficult material and, as for p layers, it is more nearly actual than before that the physical properties are not yet solved well, either. Even if Light Emitting Diode which has p-n junction is realized, the electrode formed in p layers also has many points which should still be improved, p more layers and concordance are good and the electrode material excellent in many properties is called for. Moreover, improvement in an external quantum efficiency is desired in Light Emitting Diode. Therefore, the place made into the purpose of this invention is by offering the new electrode of p layers useful as a light emitting device to realize the light emitting device excellent in the external quantum efficiency.

[0007]

[Means for Solving the Problem] The light emitting device of this invention is characterized by forming the electrode of the translucency which contains palladium (Pd) at least mostly on the whole surface of the front face of the p aforementioned layers in the nitride semiconductor light emitting device which comes to form p layers in the maximum front face.

[0008] Moreover, it is characterized by the aforementioned electrode containing at least a kind of metal chosen from the group which consists of the platinum (Pt), the rhodium (Rh), the ruthenium (Ru), the osmium (Os), the iridium (Ir), nickel (nickel), and gold (Au) other than Pd at least. These elements can maintain the translucency of an electrode, without spoiling the ohmic nature of Pd, even if it adds to Pd. In addition, the laminated structure which carried out the laminating of the thin film as electrode structure after adding is sufficient, and in the state where heat annealing of the laminated structure was carried out, and it was alloyed is sufficient, and it is good also as a state of an alloy from the beginning. Also in it, since the electrode of a bonding pad and adhesion property of Au containing Au are good, it is very desirable.

[0009] Furthermore, when making an electrode into a laminated structure, it is still more desirable that the side which touches p type layer is Pd. By making Pd into the side which touches p layers first, most things for which ohmic nature is lost are lost.

[0010] 500Å or less thickness for which a desirable translucency is maintained to the luminescence wavelength of a light emitting device is still more preferably possible for the thickness of p electrode formed in p layers in the light emitting device of this invention by adjusting to 200Å or less. This thickness is the same also about the case where the metals are made to contain besides Pd, and can maintain a desirable translucency by making the total thickness of an electrode into 500Å or less.

by 2-micrometer thickness, finally it heat-treats above 400 degrees C by the annealer, and an electrode is made to alloy.

[0024] The wafer which formed the electrode in n-type contact layer 3 and the p-layer contact layer 6 as mentioned above. Cut in the shape of [about 350 micrometer angle] a chip, and silicon-on-sapphire side 1 of the luminescence chip is pasted up with a leadframe. When wire bond is carried out by Au line, a mould is carried out by the epoxy resin and it considers as a Light Emitting Diode element, it sets to I_f (forward current) 20mA. It was 460nm in V_f (forward voltage) 3.4V and luminescence wavelength, and the radiant power output was higher than Light Emitting Diode of this structure which has p-electrode of the translucency containing conventional nickel and conventional Au about 30%.

[0025] In the [example 2] example 1, when the 100Å laminating of 20Å and the nickel was carried out for Pd to the p-electrode 10 and also the Light Emitting Diode element was obtained similarly, although it was V_f 3.4V, in I_f 20mA, the radiant power output declined about about 15% under the influence of nickel.

[0026] In the [example 3] example 1, when the 100Å laminating of 20Å and the Au was carried out for Pd to the p-electrode 10 and also the Light Emitting Diode element was obtained similarly, in I_f 20mA, it was V_f 3.4V. The radiant power output was almost equivalent to the thing of an example 2.

[0027] In the [example 4] example 1, when the 100Å laminating of 20Å and the Rh was carried out for Pd to the p-electrode 10 and also the Light Emitting Diode element was obtained similarly, in I_f 20mA, it was V_f 3.5V. The radiant power output was almost equivalent to the thing of an example 2.

[0028] In the [example 5] example 1, when the 100Å laminating of 20Å and the Ru was carried out for Pd to the p-electrode 10 and also the Light Emitting Diode element was obtained similarly, in I_f 20mA, it was V_f 3.5V. The radiant power output was almost equivalent to the thing of an example 2.

[0029] In the [example 6] example 1, when the 100Å laminating of 20Å and the Pt was carried out for Pd to the p-electrode 10 and also the Light Emitting Diode element was obtained similarly, in I_f 20mA, it was V_f 3.5V. The radiant power output was almost equivalent to the thing of an example 2.

[0030] In the [example 7] example 1, when the 100Å laminating of 20Å and the Os was carried out for Pd to the p-electrode 10 and also the Light Emitting Diode element was obtained similarly, in I_f 20mA, it was V_f 3.5V. The radiant power output was almost equivalent to the thing of an example 2.

[0031] In the [example 7] example 1, when the 100Å laminating of 20Å and the Ir was carried out for Pd to the p-electrode 10 and also the Light Emitting Diode element was obtained similarly, in I_f 20mA, it was V_f 3.5V. The radiant power output was almost equivalent to the thing of an example 2.

[0032]

[Effect of the Invention] As explained above, the light emitting device of this invention can be formed in the front face of p-layers, and can take out luminescence of a barrier layer outside effectively. And since the electrode is excellent also in ohmic nature with p-layers, V_f can realize a low practical light emitting device. When the light emitting device of this invention is used for Light Emitting Diode devices, such as for example, a full color Light Emitting Diode display, a Light Emitting Diode signal, and the traffic information plotting board, a bright device can be realized by the low power and the utility value on the industry is size.

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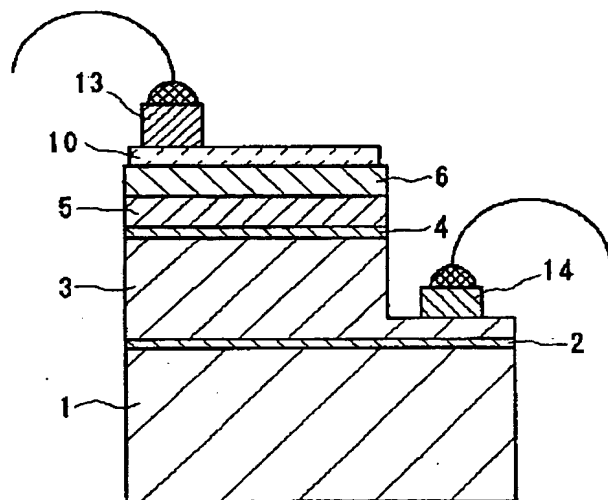
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(54)【発明の名称】窒化物半導体発光素子

(57)【要約】

【目的】 発光素子として有用なp層の新規な電極を提供することにより、外部量子効率に優れた発光素子得る。

【構成】 p型窒化物半導体層が最表面に形成されてなる窒化物半導体発光素子において、前記p型窒化物半導体層の表面のほぼ全面に、少なくともパラジウム(Pd)を含む透光性の電極が形成されているので、透光性電極を通して発光が観測でき、外部量子効率が向上する。



を維持することが可能である。この膜厚はPdの他に他の金属を含有させた場合についても同様であり、電極の総膜厚を500オングストローム以下とすることにより、好ましい透光性が維持できる。

【0011】p電極を形成するには蒸着、スパッタ等、通常の気相製膜装置を用いることができる。製膜装置により膜厚を制御して、前記のように500オングストローム(0.05 μ m)以下、さらに好ましくは200オングストローム以下の膜厚にすることにより、好ましい透光性となり、発光素子の発光を透過する。なお透光性とは発光素子の発光波長を電極が透過するという意味であって、必ずしも無色透明を意味するものではない。

【0012】本発明の発光素子はMOVPE(有機金属気相成長法)、HDVPE(ハライド気相成長法)、MBE(分子線気相成長法)、MOMBE(有機金属分子線気相成長法)等の気相成長装置を用いて、基板上に窒化物半導体の結晶を成長、積層することで作成可能である。基板にはサファイア(Al_2O_3)、ZnO、スピネル($MgAl_2O_4$)、SiC、Si、GaN等が用いられるが、サファイア、SiCが用いられることが多い。積層構造としては、基本的に基板の上にn層を成長させ、n層の上にp層を積層して、p層が最表面となるように積層して、この最表面のp層に電極を形成できる構造とする。この他、p-i-n接合して、p層が最表面とされた発光素子でもよい。n型の窒化物半導体は、例えばSi、Ge、Se等のドナー不純物をドーピングすれば成長可能である。一方、p型の窒化物半導体は、Mg、Zn等のII族元素、C等のアクセプター不純物を窒化物半導体中にドーピングすることにより成長可能である。例えば、MOVPE法を用いてアクセプター不純物をドーピングした窒化物半導体を成長させると、成長後、何の処理をしなくともp型特性を示すものもあるが、好ましくは、400℃以上でアニーリング処理を施すことにより、さらに好ましいp型特性を示すようになる。なおp型とは、例えばアクセプター不純物をドーピングした窒化物半導体で、抵抗率が $10^{-3}\Omega\cdot cm$ 以下を示す半導体をいう。

【0013】

【作用】Pdを含む透光性の電極は、可視光、特に紫色～緑色領域にかけての透過率がNiとAuよりなる従来の透光性p電極よりも優れている。従ってp層の表面に形成した場合に、窒化物半導体発光素子の光透過率が良くなるので、外部量子効率が向上する。しかも、オーミック性も非常に優れており、特にPdをp層と接する側に形成した場合、そのPdの上に他の金属薄膜を透光性の状態で形成しても、オーミック性を維持することができる。特にPt、Rh、Ru、Os、Ir、Ni、Au等の金属はPdと合金化しても、良好なオーミック性を維持できる。さらに、p電極をp層のほぼ全面に形成してあるので、電流がp層全体に均一に広がり、局部的な電界集中が起こらず、活性層全体から均一な発光が得ら

れる。

【0014】図1はp層に形成した各種電極の電流電圧特性を示すグラフである。具体的に、p層の上に次に述べる薄膜を形成した後、400℃以上でアニールしてp電極を形成し、同一種類の電極同士の電流電圧特性を測定することにより、その電極のp層に対するオーミック性を調べたものである。また、図2は図1に示す透光性電極の透過率を示すグラフである。電極は次の通りである。

【0015】A: Pdを40オングストロームの膜厚で形成した透光性電極。

B: Niを60オングストロームと、Auを200オングストロームの膜厚で順に積層形成した従来の透光性電極。

【0016】図1に示すように、両方とも良好なオーミック性は示しているが、さらにPdはp層と抵抗が低く、非常に良好なオーミック性を示していることが分かる。

【0017】また図2は各電極の透過率を示すものであるが、従来のNi-Auを含む電極(B)は窒化物半導体発光素子の発光の特徴である紫色～緑色領域にかけての透過率が悪い。これに対し、本発明の発光素子に係る電極Aの透過率は、Bに比べて優れているので、発光素子の外部量子効率を向上させることができる。

【0018】

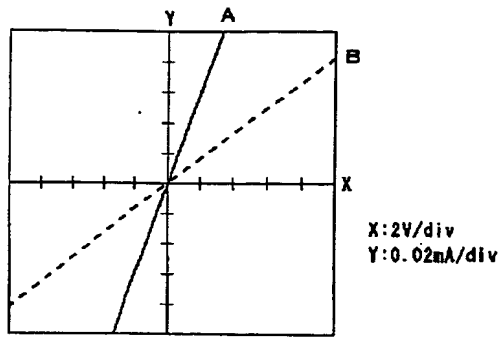
【実施例】以下、図面を基に本発明の発光素子の一実施例について説明する。図3は本発明の発光素子をp層の電極側から見た平面図であり、図4は図3の発光素子を図に示す一点鎖線で切断した際の構造を示す模式的な断面図である。

【0019】[実施例1] MOVPE反応装置を用い、2インチφのサファイア基板1の上にGaNよりなるバッファ層2を200オングストローム、Siドーピングn型GaNよりなるn型コンタクト層3を4 μ m、ノンドープIn_{0.2}Ga_{0.8}Nよりなる単一量子井戸構造の活性層4を30オングストローム、Mgドーピングp型Al_{0.1}Ga_{0.9}Nよりなるp型クラッド層5を0.2 μ m、Mgドーピングp型GaNよりなるp型コンタクト層6を0.5 μ mの膜厚で順に成長させる。

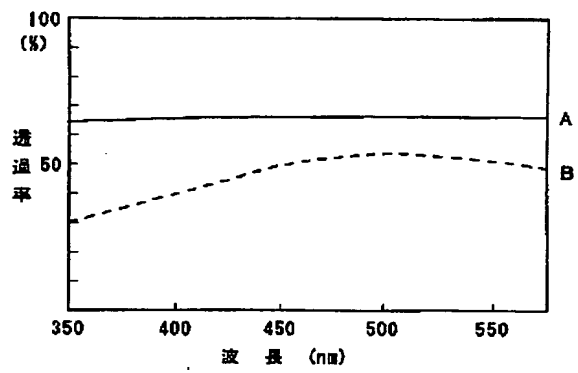
【0020】さらにウェーハを反応容器内において、窒素雰囲気中で600℃でアニーリングして、p層5、6をさらに低抵抗化する。アニーリング後、ウェーハを反応容器から取り出し、最上層のp型GaNの表面に所定の形状のマスクを形成し、エッチング装置でマスクの上からエッチングを行い、図2に示すようにn型コンタクト層3の一部を露出させる。

【0021】次に、p層の上のマスクを除去し、最上層のp型GaN層のほぼ全面に、p電極10として、Pdを30オングストロームの膜厚で蒸着する。蒸着後のPd膜は明らかに透光性となっており、サファイア基板1

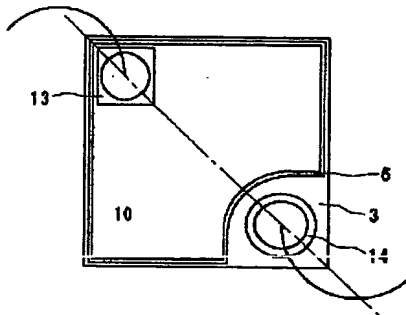
【図 1】



【図 2】



【図 3】



【図 4】

